Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Environmental Sciences 11 (2011) 1100 – 1107

Procedia Environmental Sciences

Sensing of Diesel Vehicle Exhaust Gases under Vibration Condition

Chuliang Wei[1] and Zhemin Zhuang[1], Qin Xin[2], A.I. Al-Shamma'a[3] and A. Shaw[3]

[1]*Department of Electronic Engineering, Shantou University Shantou, Guangdong Province, China*

[2]*Simula Research Laboratory Oslo, Norway*

[3]*The BEST Research Centre Liverpool John Moores University Byrom Street, Liverpool , U.K.*

{clwei & zmzhuang}@stu.edu.cn, xin@simula.no , {a.al-shamma'a & a.shaw}@ljmu.ac.uk

Abstract

To better understand diesel road vehicle exhaust gases and then reduce these harmful exhaust gases, the harmful gases, such as carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO2), hydrocarbon (HC), and sulphur dioxide (SO2) from a diesel engine are monitored and studied. During the monitoring, the engine is run at various states, such as the lowest constant speed or the regularly changing speed. These various engine running states cause different engine vibration conditions. The study shows that the diesel engine run at various states discharges different levels harmful exhaust gases, and the measurement results of the gas sensors are not affected by engine vibration. This study brings a future development of the microwave catalyst based system for the reduction of harmful exhaust gases from diesel engines.

Keywords: gas sensor; vehicle exhaust gas; harmful exhaust gas reduction; engine vibration.

1. Introduction

The increase in world economic prosperity has resulted in more and more road vehicle being used. These road vehicles improve the quality of people's life in terms of convenience. However road vehicles are the major pollution sources which seriously harm human health and the environment worldwide. A series of directives for limiting vehicle pollution have been introduced particularly in the EU, USA, China and Japan. Presently many investigations are being carried out in order to find out more effective ways to reduce the vehicle pollution by using precise measurement of vehicle pollution. This paper presents the details of monitoring and studying of harmful exhaust gases, such as carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO2), hydrocarbon (HC) and sulphur dioxide (SO2) from a diesel vehicle engine in various engine running states. The various engine running states, such as the highest speed and the lowest speed, cause different engine vibration conditions. To find out whether the measurement of

doi:10.1016/j.proenv.2011.12.166

exhaust gases using gas sensors is affected by the vibration condition, the vibration sensors are mounted on the diesel engine for vibration monitoring, as shown on the inset of Fig. 1, and the gas sensors are installed by using two methods: one is mounted in the flue of the engine, i.e. the engine vibrates the gas sensors, as shown on Fig. 1; the other is mounted on a laboratory bench, i.e. the sensors are not affected by the engine vibration.

The system is built by two subsystems: gas sensing subsystem and vibration monitoring subsystem. Fig. 2 shows the layout of the system setup. The gas sensing subsystem mainly consists of a commercial gas analyzer, named Kane May 9106 (KM9106) Quintox Combustion Analyzer [1], which has five gas sensors, i.e. the CO, NO, NO2, HC, and SO2 sensors. These five sensors are embedded into a probe with the purpose of easily installation. The vibration monitoring subsystem is based upon a developed PCB which includes an x-axis and a y-axis accelerometers. A control computer is employed to study the data captured from those sensors.

Figure 1. The probe of the KM9106 Quintox Combustion Analyzer installed in the flue of the engine. Inset shows the vibration monitoring PCB mounted on the engine

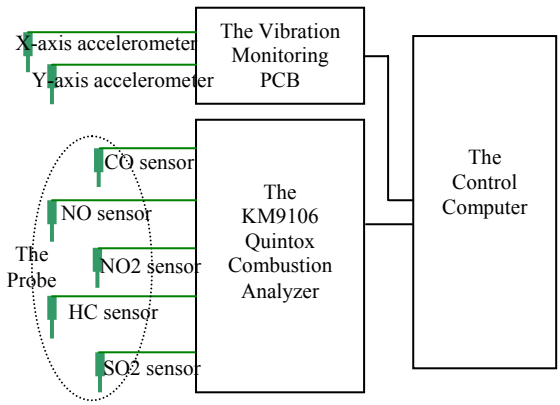


Figure 2. The layout of the system setup

2. Gas sensing subsystem

This subsystem employs the KM9106 Quintox Combustion Analyzer to sense the levels of the gases. The introduction of the analyzer and the field test results are described as below.

2.1KM9106 Quintox Combustion Analyzer

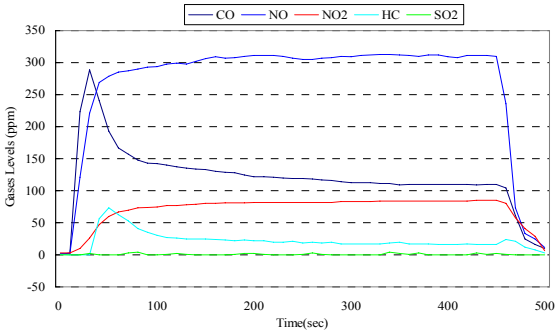
The KM9106 Quintox Combustion Analyzer, as shown on Fig. 3, comprises the main analyzer box, the probe, and the control handset. It is able to measure CO, NO, NO2, HC and SO2 levels whose ranges and resolutions are shown in Table I [1]. The majority designs of the sensors have an electrochemical analysis approach, while the HC sensor is based on the non-dispersive infrared absorption method. The sample rate of the analyzer is one sample per ten seconds, and the captured data is transmitted to the control computer for analysis by using a RS232 cable.

2.2Field Test Results

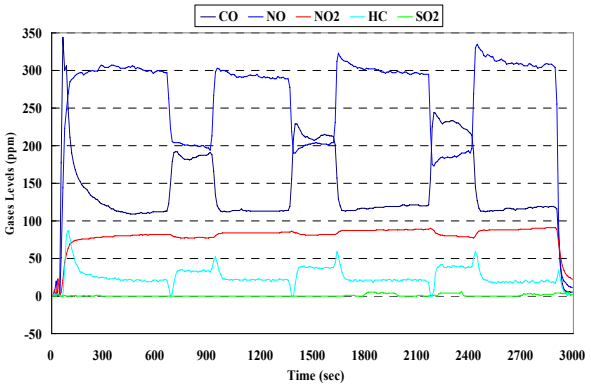
The test results are shown on Fig. 4. Fig. 4(a) shows the results of a short-time test in which the engine is run at the highest constant speed, and the gas sensors are mounted on the engine. Fig. 4(b) shows the results of a fifty minutes test in which the engine is run under regularly changing speed, and the gas sensors are mounted on the engine. Fig. 4(c) shows the results of a fifty minutes test in which the engine is run under regularly changing speed, and the gas sensors are not mounted on the engine. These results show that: (1) the level of each type of gas is increased at the beginning of about fifty seconds because the engine is at the increasing speed running state; (2) the level of each type of gas is decreased at the end of about fifty seconds because the engine is at the decreasing speed running state; and (3) the results of Figs. 4(b) and (c) are nearly repeatable because the engine running states of both tests are so similar, although Fig. 4(b) shows the results in which the sensors are vibrated by the engine and Fig.4(c) shows the results in which the sensors are not vibrated by the engine. As a consequence, these results show that the diesel engine running at various states discharges different levels harmful exhaust gases, and the measuring results of every gas level are not affected by the vibration of the sensors.

The Probe

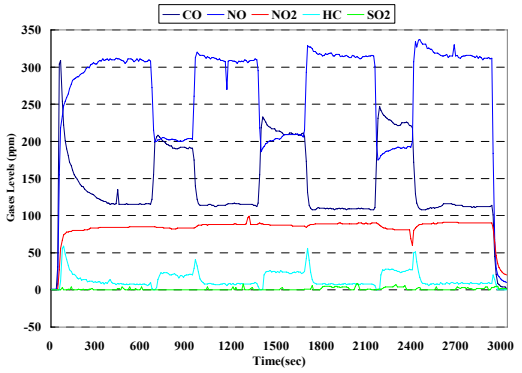
Figure 3. The KM9106 Quintox Combustion Analyzer



(a)



(b)

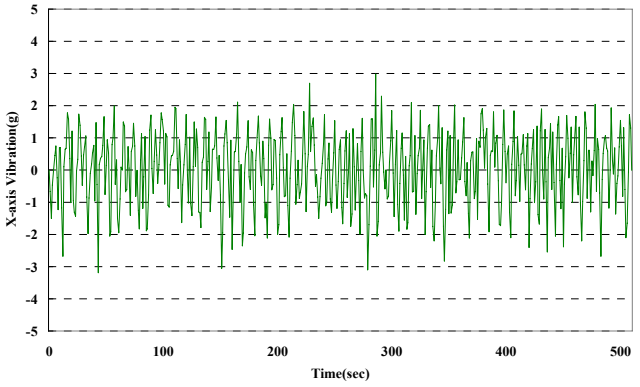


(c)

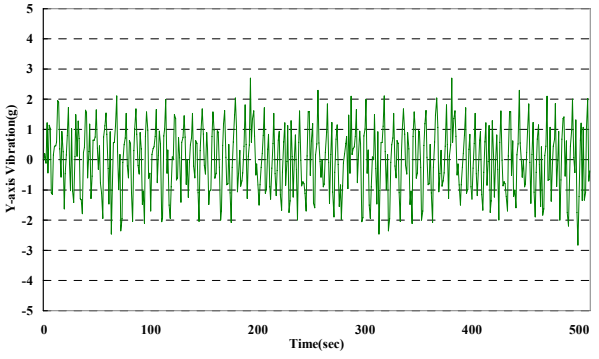
Figure 4. Test results of vehicle exhaust gases: (a) under the highest speed engine running state, and the sensors are mounted on the engine; (b) under regularly changing speed engine running state, and the sensors are mounted on the engine; (c) under regularly changing speed engine running state, the sensors are not mounted on the engine

3. Vibration monitoring subsystem

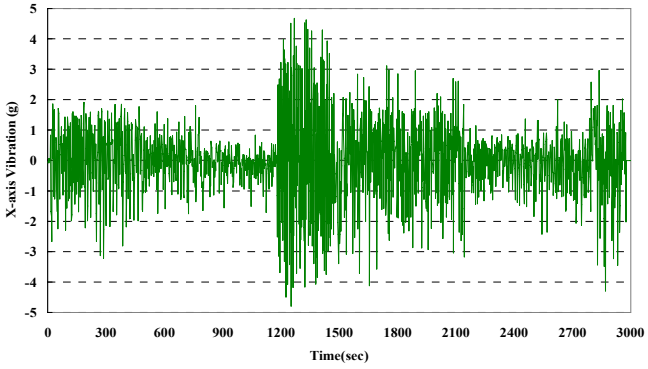
An accelerometer chip ADXL210 with the measurement range of ±10g [2], a multi-channel RS232 driver chip MAX233, and a micro controller chip PIC18F458 are used to built a PCB to measure the x-axis and y-axis engine vibration. Fig. 5 shows the monitoring results. Figs. 5(a) & (b) shows the x-axis and y-axis vibration results respectively in which the engine is run at the highest constant speed, and at that time, the engine exhaust gases are also measured and the results are shown on Fig. 4(a). Figs. 5(c) & (d) shows the x-axis and y-axis vibration results respectively in which the engine is run under regularly changing speed, and at that time, the engine exhaust gases are also measured and the results are shown on Fig. 4(b). Figs. 5(e) & (f) shows the x-axis and y-axis vibration results respectively in which the engine is run under regularly changing speed, and at that time, the engine exhaust gases are also measured and the results are shown on Fig. 4(c). These results show that: (1) the engine x-axis vibration levels follow by the change of engine speeds, while the y-axis vibration levels are not affected by the change of engine speeds; (2) the results of Figs. 5(c) & (e) are nearly repeatable, and Figs. 5(d) & (f) are also repeatable because the engine running states of these tests are so similar.



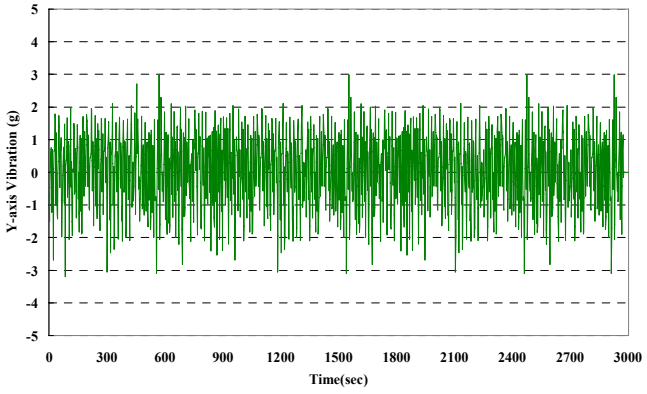
(a)



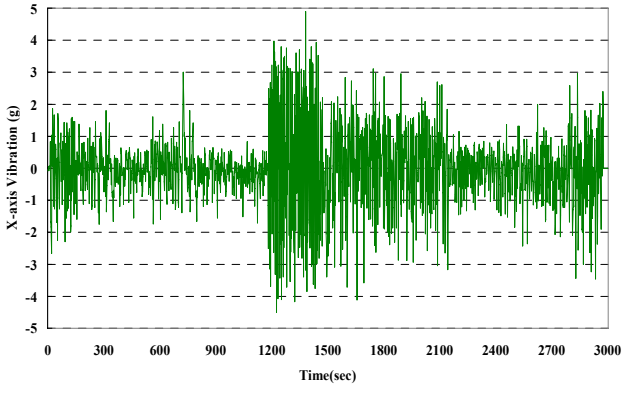
(b)


X-axis Vibration (g)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
300
600
900
1200
1500
1800
2100
2400
2700
3000
Time(sec)

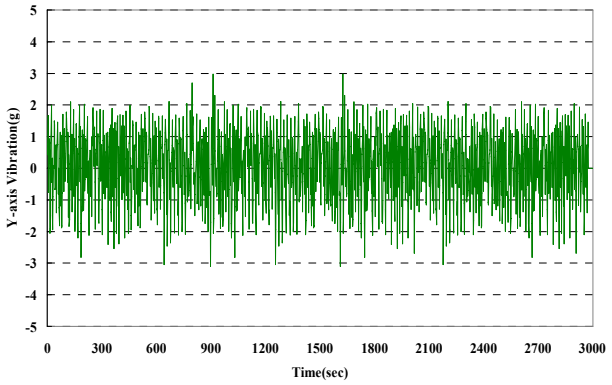
(c)


Y-axis Vibration (g)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
300
600
900
1200
1500
1800
2100
2400
2700
3000
Time(sec)

(d)


X-axis Vibration (g)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
300
600
900
1200
1500
1800
2100
2400
2700
3000
Time(sec)

(e)



(f)

Figure 5. Test results of engine vibration: (a) & (b) x-axis and y-axis vibration respectively under the highest speed engine running state; (c) & (d) x-axis and y-axis vibration respectively under regularly changing speed engine running state; (e) & (f) x-axis and y-axis vibration respectively under regularly changing speed engine running state

Table 1. gas measurable resolutions and ranges of the km9106 quintox combustion analyzer

Gas	Resolution	Range
CO	1ppm	0 – 10000ppm
NO	1ppm	0 – 5000ppm
NO2	1ppm	0 – 1000ppm
HC	10ppm	0 – 3000ppm
SO2	1ppm	0 – 1000ppm

4. Conclusions and future application

This study shows that the harmful engine exhaust gases levels follow by the change of engine speeds, and the measuring results of the gas sensors are not affected by the engine vibration. In addition, this investigation shows that the measured levels of each type of gas are within the certain value ranges that are forecasted and reasonable, thus these gas sensors are accurate and authentic, and they are capable to be future employed in the test of the microwave catalyst based system [3-6] which is being developed in the BEST Research Centre of Liverpool John Moores University. The microwave catalyst based system is able to reduce harmful exhaust gases from both diesel and petrol road vehicles.

Acknowledgement

The authors would like to express their appreciation to financial support from Shantou University and Liverpool John Moores University.

References

[1]Keison Products, “KM9106 Operators Manual” Chelmsford, U.K., http://www.keison.co.uk, 2010.

[2]Analog Devices, Inc., “ADXL210 Data Sheet”, 2010.

[3]A.I. Al-Shamma’a and J. Lucas, “Exhaust Gas Reactor”, British patent 0302905.5(WO04/070175), 2004.

[4]L.E. Cordova Lopez, A.I. Al-Shamma’a, A. Shaw, S.R. Wylie, and J.D. Cullen, “A Microwave Plasma Catalytic System to Reduce Exhaust Pollutants” GERI Annual Research Symposium, ISSN: 1757-6717, U.K., June 2009.

[5]S.R. Wylie, A.I. Al-Shamma’a, J. Lucas, “UK Foresight Vehicle: 2.45ghz Microwave Atmospheric Plasma For Cleaning Exhaust Gases And Particulates”, Proc. of the XIV Int. Conf. on Gas Discharges and Their Applications, Liverpool, U.K., Vol. 2, pp 32-35, September 2002.

[6]A.I. Al-Shamma’a and A. Shaw, “All-Optical Sensing Deals With Vehicle Emissions”, Opto & Laser Europe, Issue 129, pp 47-48, June 2005.